Unit Overview – Socially Responsible Engineering & Technology (POS)
Course: YIU5
Unit Title: Is Recycling Worth the Time?
Approximate Length of Unit: 8-10 Weeks (based on five day weeks; 45 minute periods each day)

Unit Summary

This unit will raise student interest in principles of structural, mechanical, and electrical engineering through the application of multiple control systems. Students will be presented with the following problem.

Americans generate over four pounds of waste per person per day. Rising costs of production, packaging, and transportation highlight the need for more efficient and more widespread means of recycling by all parties. As population continues to increase, problems with garbage disposal and the need for more product reusability continue to challenge mankind. Growing awareness has resulted in recycling emerging as a necessary trend in homes, businesses, and communities. However, the need for a more efficient means of sorting and transportation exists. In a design team of two, students will design, fabricate, and demonstrate the application and control of mechanical, fluid, and electrical power by sorting various recycled materials with a device that applies power and energy principles. By executing the steps of the engineering design process, students will work cooperatively to brainstorm, develop, and explain the real world value of their working prototype.

Throughout the unit, students will also acquire technical skills that employ planning and time management skills and tools to enhance results and complete work tasks, while concurrently demonstrating proper application of math and science skills to enhance function and performance.

Primary interdisciplinary connections: Math, Science

21st century themes: Global Awareness, Civic Literacy, Environmental Literacy

Unit Rationale:

According to the United States Environmental Protection Agency, 243 million tons of waste was generated in the United States in 2009. This translates to over four pounds of waste per person each day. Homes, businesses, and communities have initiated aggressive efforts to minimize waste by encouraging product reusability through greener production methods, less packaging, and through recycling of more household items. High school students challenged with the prospect of rising tuition when they go to college can appreciate the importance of efforts to reduce supply, transportation, and food costs through more efficient recycling. Current and future careers in engineering will focus on product sustainability and reusability, and student focus on this real world problem will provide the technical and interdisciplinary skills needed for a 21st century workforce.

Learning Targets

Standards for Technological Literacy :

Standard 9: Students will develop an understanding of the engineering design.

J. Engineering design is influenced by personal characteristics, such as creativity, resourcefulness, and the ability to visualize and think abstractly.

Standard 10: Students will develop and understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

L. Many technological problems require a multidisciplinary approach.	
Science (NJCCCS 5) **5.1 Science Practices -** All students will understand that science is both a body of knowledge and an evidence based, model-building enterprise that continually extends, refines, and revises knowledge. The four Science Practices strands encompass the knowledge and reasoning skills that students must acquire to be proficient in science.	
CPI#	**Cumulative Progress Indicators (CPI)**
5.1.12.C.1	Reflect on and revise understandings as new evidence emerges.
Science (NJCCCS 5) **5.2 Physical Science -** All students will understand that physical science principles, including fundamental ideas about matter, energy, and motion, are powerful conceptual tools for making sense of phenomena in physical, living, and Earth systems science.	
CPI#	**Cumulative Progress Indicators (CPI)**
5.2.12.E.4	Measure and describe the relationship between the force acting on an object and the resulting acceleration.
Mathematics (NJCCCS 4) **4.2 Units of Measurement -** Measurement helps describe our world using numbers. An understanding of how we attach numbers to real-world phenomena, familiarity with common measurement units (e.g., inches, liters, and miles per hour), and a practical knowledge of measurement tools and techniques are critical for students' understanding of the world around them.	
CPI#	**Cumulative Progress Indicators (CPI)**
4.2.12 D.2	Choose appropriate tools and techniques to achieve the specified degree of precision and error needed in a situation.
Educational Technology (NJCCCS 8.1) **8.1 Educational Technology:** All students will use digital tools to access, manage, evaluate, and synthesize information in order to solve problems individually and collaboratively and to create and communicate knowledge.	
CPI#	**Cumulative Progress Indicators (CPI)**
8.1.4.A.3	Create and present a multimedia presentation that includes graphics.
Engineering and Technological Literacy (NJCCCS 8.2) **8.2 Technology Education, Engineering, and Design -** All students will develop an understanding of the nature and impact of technology, engineering, technological design, and the designed world, as they relate to the individual, global society, and the environment.	
CPI#	**Cumulative Progress Indicators (CPI)**
8.2.12.F.1	Determine and use the appropriate application of resources in the design, development, and creation of a technological product or system.
8.2.12.G.1	Analyze the interactions among various technologies and collaborate to create a product or system demonstrating their interactivity.
21ST Century Skills (NJCCCS 9.1) **Standard 9.1 21st Century Life & Career Skills:** All students will demonstrate the creative, critical	

thinking, collaboration, and problem solving skills needed to function successfully as both global citizens and workers in diverse ethnic and organizational cultures.	
CPI #	**Cumulative Progress Indicator (CPI)**
9.1.12.B.1	Present resources and data in a format that effectively communicates the meaning of the data and its implications for solving problems, using multiple perspectives.
Standard 9.4 Career and Technical Education All students who complete a career and technical education program will acquire academic and technical skills for careers in emerging and established professions that lead to technical skill proficiency, credentials, certificates, licenses, and/or degrees.	
CPI #	**Cumulative Progress Indicator (CPI)**
9.4.12.O.17	Employ critical thinking skills (e.g., analyze, synthesize, and evaluate) independently and in teams to solve problems and make decisions.
9.4.10.O.(1).4	Demonstrate the ability to use Newton's Laws of motion to analyze static and dynamic systems with and without the presence of external forces.
9.4.12.O.(1).11	Demonstrate understanding of processes and concepts that are key to understanding the design process.
Industry Standards –	
NOCDI –	
▪ STEM – Pre-Engineering, Engineering Technology	
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Design Brief

Background/Scenario:
Americans generate over four pounds of waste per person per day. Rising costs of production, packaging, and transportation highlight the need for more efficient and more widespread means of recycling by all parties.

Problem/Opportunity Statement:
In a design team of two, students will design, fabricate, and demonstrate the application and control of mechanical, fluid, and electrical power by sorting recyclable materials with a device that applies power and energy principles.

Specifications/Criteria:

- Evaluation is based upon a timed demonstration of the mechanical, fluid, and electrical energy principles and craftsmanship.
- Timing begins when the participant dumps the official mixture of materials in the device hopper. The hopper must be large enough to hold the mixture of $2.50 of quarters, dimes and nickels; 20 poker chips; a mixture of twenty (20) machine washers, which vary in size from ½" outside diameter to 1¼" inch outside diameter; ten (10) paper baker's cups (cup cake liners); ten ⅝" marbles; and five (5) AA batteries.
- Teams get two official demonstrations.

Constraints:

Time –
- Maximum demonstration time is three minutes.

Money -
- No limit

Energy –
- Fluid power cannot exceed 35 psi.
- Flammables and wet cell batteries are not permitted.

- A maximum of two, six-volt lantern batteries can be used.

Tools/Machines

- Use safety as needed.
- Standard hand tools, table top material processing machines, electronics components, batteries, testing equipment (stopwatch, voltmeter)

People

- Maximum of two people per group

Information

- Acquired through lessons and past experiences

Materials

- Recycled materials only
- Recycled materials are readily available regardless of regional or demographic differences. Teacher must supply those items to be sorted.

Stakeholders:

- All students who will advance in course outline.
- All students who are looking to pursue career in engineering or technical field.

Student Grouping Notes:

- Groups of two will allow both parties to be involved in brainstorming, design, and documentation. Larger groups will garner a less efficient distribution of tasks.

Material Notes:

- Items that are being sorted can be changed accordingly based on availability and budget. Teacher can change the number of demonstrations each design team gets as well.

Unit Essential Questions	**Unit Enduring Understandings**
• Is product sustainability the responsibility of the manufacturer or consumer? • Is recycling worth the time? • Is recycling the most efficient way to minimize waste? • What methods can make recycling more user friendly? • How should recycling advocates address those who do not recycle? • How do different personnel function together on a design project? What personnel is required to manage all of the experts involved in a project? • How does a design team member work effectively to be a productive person of a team?	• Technological systems contain a variety of mechanical, electrical, and fluid sub systems. • Recycling can be facilitated through an effective application of technology. • Testing and re evaluation should be conducted through the design process. • Effective group communication enhances product function and efficiency. • Direct human interaction is not necessary in order for a product to meet its desired goal.

Unit Learning Targets

Throughout the unit, students will acquire insights into various applications of electrical, mechanical, and fluid power. In addition, they will cooperatively apply applications of each type of power to meet the goal of efficient product recycling. The nature of this particular engineering design will require enhanced communication, testing, and continuous evaluation.

Students will ...

1. Review the steps of the engineering design process. (8.2.12.F.1)
2. Research the current environmental, social, and economic impacts of recycling. (8.2.12G.1)
3. Research the material properties and behaviors of those items being sorted. (5.2.12.E.4)
4. Apply an understanding of how products are sorted as a component of the recycling process. (8.2.12.G.1)
5. Demonstrate the use of critical thinking skills to select appropriate applications of energy and power. (ITEEA10L)
6. Explore appropriate materials and fasteners needed for the fabrication of the solution. (4.2.12.D.2)
7. Evaluate and re-design the solution as needed throughout the design process. (5.1.12.C.1) (ITEEA9J) (9.4.12.O.(1).11)
8. Establish the sub-systems that need to function prior to assembly. (9.4.10.O.(1).4)
9. Demonstrate reliability and repeatability in the function of the solution. (8.2.12.F.1)
10. Acquire and evaluate accurate test results to develop objective conclusions. (9.1.12.B.1)
11. Present project design and rationale to peers. (8.1.4.A.3)

<table>
<tr><th colspan="2">Project-Based Learning Plan:
Engineering Design Process (Sequence and Assessments)</th></tr>
<tr><th>Teacher Instruction</th><th>Student Evaluation</th></tr>
<tr><td colspan="2">Step One: Identify the Problem</td></tr>
<tr><td>Lesson 1:
• The Impacts of Recycling
Lesson 2:
• Review Engineering Design Process</td><td><u>Formative Assessments (must have feedback):</u>
• Student design teams will assess the current state of recycling and identify any inefficiency, noting findings in their learning logs.
• Student design teams will collaborate with other design teams to share findings and propose solutions.
• Teacher and other design teams will share information and provide feedback on findings and solutions.
• Teacher will show students examples of the kind of test items that might appear on written exams and quizzes in this unit.

<u>Summative Assessments:</u>
• Steps of Engineering Design Process Quiz (ULT #1)
• Test – Impacts of Recycling (ULT#2 and ULT#4)</td></tr>
<tr><td>Notes:
Teacher will introduce the current problems in regard to waste disposal, over population, product lifespan, and sustainability.   Teacher will review the steps of the engineering design process and discuss how the steps were implemented in previous years/projects.</td><td>Notes:</td></tr>
<tr><td colspan="2">Step Two: Frame the Design Brief</td></tr>
<tr><td>Lesson 3: Framing the design brief for the recycling project
• Review of design brief requirements
• Review of specifications
• Review of constraints</td><td><u>Formative Assessments:</u>
▪ Using teacher prepared rating scale, students will rate themselves on clean up and organization.
▪ Teacher will conference with each two-person design team to review and provide feedback on specifications of the design brief.

<u>Summative Assessments:</u>
▪ Performance assessment with rating scale: Students will demonstrate proper clean up procedure. (ULT#6)
▪ Quiz - Primary constraints and</td></tr>
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<tr><td></td><td>specifications of design brief. (ULT#3)</td></tr>
<tr><td>Notes:</td><td>Notes:</td></tr>
<tr><td colspan="2">Step Three: Research & Brainstorming</td></tr>
<tr><td>Lesson 4:
• Power Systems: Types, advantages, and disadvantages of mechanical, electrical, and fluid power systems</td><td><u>Formative Assessments:</u>
▪ Student design teams will brainstorm how various mechanical, electrical, and fluid power systems could be incorporated into their sorting machine and include them in learning logs.
▪ Teacher will conference with design teams to stimulate brainstorming.

<u>Summative Assessments:</u>
▪ Written Exam - Types/applications of power systems (ULT#5)</td></tr>
<tr><td>Notes:</td><td>Notes:
Teacher will encourage student analysis of the design brief and require research of mechanical, electrical, and fluid systems.

Teachers will actually observe and dialogue with students about design possibilities. Teacher will continually highlight need to conserve materials and use recycled resources.</td></tr>
<tr><td colspan="2">Step Four: Generation Alternate Solutions</td></tr>
<tr><td>Lesson 5:
▪ Materials and Fasteners
Lesson 6:
▪ Communicating Possible Solutions</td><td><u>Formative Assessments:</u>
▪ Teacher will critique sketches of possible solutions, focusing on proper use of materials and fasteners.
▪ Teacher will review the rubric criteria and possibly show students examples of papers receiving different rubric scores if available
<u>Summative Assessments:</u>
▪ Paper with rubric – Communicating the formal bill of materials and project designs to instructor (3 minimum) (ULT #3, #5)</td></tr>
<tr><td>Notes:
Multiple days must be allocated for this step. Teacher should encourage students to explore as many different materials options as possible, as long as they are recycled materials.</td><td>Notes:
Students should evaluate material properties of the options available to them. Design brief should be readily available at all times.

Teacher will establish meeting times with each group to discuss formal possible solutions. Teacher will communicate need for completed, annotated sketches with detailed bill of materials.</td></tr>
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Step Five: Chosen Solution with Rationale	
Lesson 7: ▪ Explaining and Defending the Best Solution	**Formative Assessments:** ▪ Teacher will continue to critique sketches of sorting system and return them to design teams if more detailed sketches are required. ▪ Peers of design teams will assess solutions for completeness and accuracy and offer feedback. ▪ Review presentation rubric with students prior to final presentation. ▪ After graded presentation, teacher will collect solutions with detailed rationales and drawing, provide feedback, and return the work to students with revisions. **Summative Assessments:** ▪ Presentation with rubric – Students share best solution. (ULT#6, #8, #11)
Notes:	**Notes:** Students must continue to check their design versus the specifications of the design brief.
Step Six: Developmental Work	
Lesson 8: The Value of a Production Timeline	**Formative Assessments:** ▪ Teacher will keep anecdotal records in regard to proper tool and machine usage. **Summative Assessments:** • None
Notes: Teacher must encourage students to consistently communicate about how the mechanical, electrical, and fluid parts will work with one another.	**Notes:** Students will develop timeline for how and when different subsystems will be developed.
Step Seven: Prototype	
Lesson 9: Classroom Organization/Citizenship and Tool Usage	**Formative Assessments:** ▪ Internal group members will continuously self-assess group documentation for accuracy and completeness. ▪ Teacher will keep anecdotal records during building, fabrication, and assembly process and provide feedback as needed. ▪ Teacher will continue to keep anecdotal records in regard to safety and classroom

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<tr><td></td><td>citizenship and provide periodic feedback to maintain classroom structure.

Teacher will question students during the re-design process to clarify problems and guide improvement.
Teacher will review rubric with students to assess proper tool usage and clean up criteria.

<u>Summative Assessments:</u>

Demonstration w/ rubric: Proper tool usage and classroom clean up (ULT #6).
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<tr><td>Notes:
Teacher will ensure that all students complete tasks with an ongoing emphasis on safety, teamwork, and compromise.

Significant time must be allocated for material processing, assembly, and testing.</td><td>Notes: Students must consider trade offs and nature of material prior to re-design. Design brief must remain readily available.

Students will use previously developed resources to begin the prototype of their recycling sorter.</td></tr>
<tr><td colspan="2">Step Eight: Testing and Evaluation</td></tr>
<tr><td>Lesson 10: Review Prototype Testing Procedures</td><td><u>Formative Assessments:</u>

Teacher will continue anecdotal records in regard to safety and classroom citizenship.
Peer assessment of other solutions and their documentation. Feedback will be required and used as potential guide to re-design.
Teacher will review testing criteria before students begin formal testing.
After prototype testing, teacher will conference with students to evaluate results and generate feedback.

<u>Summative Assessments:</u>

Demonstration w/rubric: Students will officially test their prototype two times. Results will be documented (ULT #9, #10)
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<tr><td>Notes: Teacher must ensure all students are following proper safety procedures prior to and during testing.</td><td>Notes:</td></tr>
<tr><td colspan="2">Step Nine: Redesign and Reflect</td></tr>
<tr><td>Lesson 11: Review – Writing a Technical Reflection</td><td><u>Formative Assessments:</u>

Teacher will conference with each design
</td></tr>
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Paper	team to evaluate and provide feedback on their mechanical, electrical, and fluid applications. ▪ Teacher will review technical reflection paper rubric and provide examples of papers receiving various rubric scores if available. **Summative Assessments:** At the end of steps eight and nine, as measured by a rubric, designated team members will be responsible for: ▪ Reflection Paper: How can control systems be applied to efficiently sort recycled materials? (ULT #7)
Notes: After providing time for two formal tests, instructor will provide time for a class wide discussion on the merits and of this unit. Discussion will highlight the performances of each group and seek feedback of an overall impression of the process.	**Notes:**
Step Ten: Communicate	
Lesson 12: Delivering Effective Presentations	**Formative Assessments:** ▪ Students will practice using presentation software/equipment delivery, including pacing, presence, and readability. Using the rubric they will be evaluated on, peers and instructor will provide feedback on what to improve. **Summative Assessments:** ▪ Performance activity w/rubric: Presentation of completed system to peers. (ULT#11)
Notes:	**Notes:** Teacher will establish timeframe for student presentation and demonstration for the entire class. Classmates are encouraged to provide critical, constructive feedback. Students should demonstrate performance of sorting system as component of the formal presentation. Students should emphasize core principles of mechanical, electrical, and fluid systems during presentation.
Corresponding Technology Student Association (TSA) Activities	
Engineering Design **Technology Challenge (ret.)**	

Curriculum Development Resources
United States Environmental Protection Agency
www.epa.gov
Technology Student Association
www.tsaweb.org

Lesson Plans	
Lesson	**Timeframe**
Lesson 1 The Impacts of Recycling	45 minutes / 3 days
Lesson 2 Review Engineering Design Process	45 minutes / 1 Day
Lesson 3 Framing the Design Brief for the Recycling Project	45 minutes / 2 days 1 day to present specifications, 1 day to guide classroom Q/A
Lesson 4 Power Systems: Types, advantages, and disadvantages of mechanical, electrical, and fluid power systems	45 minutes / 2 days 1 day lecture, 1 day discuss examples
Lesson 5 Materials and Fasteners	45 minutes / 1 day
Lesson 6 Communicating Possible Solutions	45 minutes / 6 days ½ day to review expectations, 5.5 days to generate ideas.
Lesson 7 Explaining and Defending the Best Solution	45 minutes / 2 days ½ day to review options, 1.5 days to produce document
Lesson 8 The Value of a Production Timeline	45 minutes / 1 day ½ day to review options, ½ to produce draft timeline
Lesson 9 Classroom Citizenship and Safety and Tool Usage	45 minutes / 20 days 1/2 day to review expectations, 19.5 days to develop prototype
Lesson 10 Review Prototype Testing Procedures	45 minutes / 3 days 3 formal days to test
Lesson 11 Review - Writing a Technical Reflection Paper	45 minutes / 1 day
Lesson 12 Delivering effective presentations	45 minutes / 4 days ½ day to review, 3.5 days for all groups to present
Teacher Notes:	
Curriculum Development Resources	